Graphics As an Enabling Technology

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Where Is Computer Graphics Today?

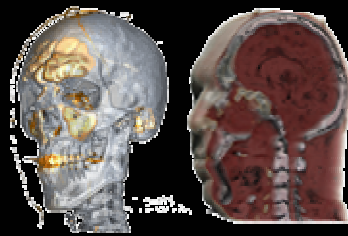*Realistic rendering and animation is becoming a solved problem*

Animation Courtesy of Ron Fedkiw

Where Is Computer Graphics Today?

Realistic rendering and visualization in realtime

Images courtesy of Joe Kniss

What Is Left?

Still improvements to be made in rendering, modeling, and animation

- Change is happening at small increments

Computational / data issues

The Data Deluge

Gigabytes to terabytes of data for most applications

Example 1: movie simulations of natural phenomena

- Water dynamics computed on a large 3D grid
- Millions of tracking particles
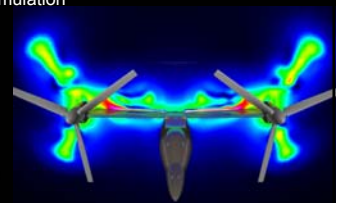- Artists add detail because of simulation expense

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The Data Deluge

Example 2: scientific visualization of Osprey-like aircraft

- 7.4 million tetrahedra in simulation
- 1362 timesteps
- Multiple data values per grid point (velocity, vorticity, etc.)
- Very long simulation and visualization time on large machines

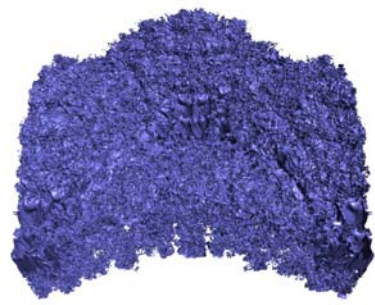Visualization courtesy of Mississippi State Engineering Research Center

The Data Deluge

Example 3: scientific visualization of turbulent mixing

- 8 billion voxels per timestep
- 274 timesteps
- Terabytes of data

Visualization courtesy of Mark Duchaineau, Peter Lindstrom, et al., Lawrence Livermore National Labs

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Data Deluge Result

- *Data size becomes a computational and transfer bottleneck*
- *For many datasets or simulations, you could never look at the entire dataset in detail*
- *Computation time wasted on unimportant details or details that are never seen*
- *A different approach is needed*

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The Important Questions Become

- *How to effectively convey information to the user?*
- *What should be drawn / highlighted?*
- *How can they gain insight?*

- Creating images to convey information / story to humans
- Artists and illustrators have known this for centuries!

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The Future of Graphics

Graphics is most powerful when combined with

- Effective enhancement / extraction of information
- Perception research
- Art / illustration techniques
- Improved interaction

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The Future of Graphics

Part of a larger solution

- Biggest pay-off when effectively combined in a solution to a larger problem
- Applications will drive the major advances in CG & HCI
- Rendering and animation will only be one component of the next major advances

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Example: The Merry Drinker by Frans Hals (1627)

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Detail of The Merry Drinker

Willem Claesz Heda,
Still Life with Gilt Cup, 1635

Role of Perception

- *Only need to compute visually accurate images!*
  - Why do you want true physics if the viewer can't see the difference?
- *Perception can guide where the computational effort should go*
- *Can increase the communication bandwidth by harnessing several perceptual channels*

Solution Strategy: Procedural Techniques

- *Use computational horsepower of GPUs to create needed detail on the fly*
- *Overcomes bandwidth data bottleneck*
- *Generate perceptually-tuned procedures*
  - Generate the perceptually significant portions of the data
- *Incorporate artistic and illustration techniques*
  - Enhance the image effectiveness
- *Allow interaction at an effective, perceptually manageable level*

Example: Simple Procedural Effect

Only 40 numbers needed to create this complexity

Easily controlled through intuitive parameters

Conclusion

- *Harnessing perception and procedural techniques will create effective images at interactive rates*
- *Users don't want to or can't see the entirety of many datasets / simulations*
- *Use of illustration and artistic techniques combined with perceptual principles is incredibly powerful*